



# Quad Matched 741-Type Operational Amplifiers

## OP-09/OP-11

### FEATURES

- Guaranteed  $V_{os}$  ..... 500 $\mu$ V Max
- Guaranteed Matched CMRR ..... 94dB Min
- Guaranteed Matched  $V_{os}$  ..... 750 $\mu$ V Max
- RC/RM4136 Direct Replacement (OP-09)
- LM148/LM348 Direct Replacement (OP-11)
- Low Noise
- Silicon-Nitride Passivation
- Internal Frequency Compensation
- Low Crossover Distortion
- Continuous Short-Circuit Protection
- Low Input Bias Current
- Available in Die Form

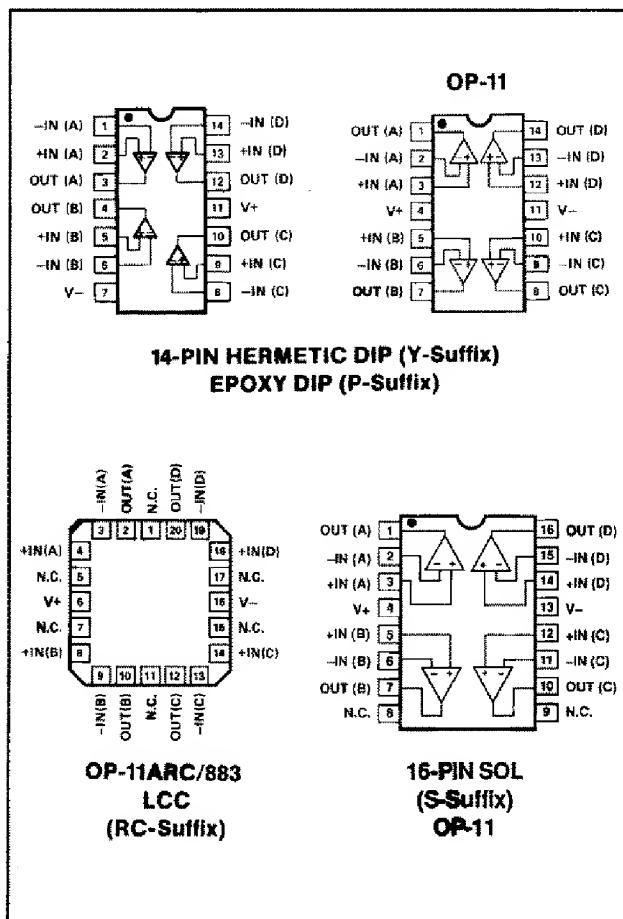
### ORDERING INFORMATION <sup>†</sup>

| $T_a = +25^\circ\text{C}$ | $V_{os}$<br>MAX<br>(mV) | PACKAGE          |                       | OPERATING<br>TEMPERATURE<br>RANGE |
|---------------------------|-------------------------|------------------|-----------------------|-----------------------------------|
|                           |                         | CERDIP<br>14-PIN | PLASTIC<br>20-CONTACT |                                   |
| 0.5                       | OP09AY*                 | —                | —                     | MIL                               |
| 0.5                       | OP11AY*                 | —                | OP11ARC/883           | COM                               |
| 2.5                       | OP11BY*                 | —                | —                     | MIL                               |
| 2.5                       | OP11FY                  | OP09FP           | —                     | XIND                              |
| 5.0                       | OP11CY/883              | —                | —                     | MIL                               |
| 5.0                       | —                       | OP11GP           | —                     | XIND                              |
| —                         | —                       | OP11GS           | —                     | —                                 |

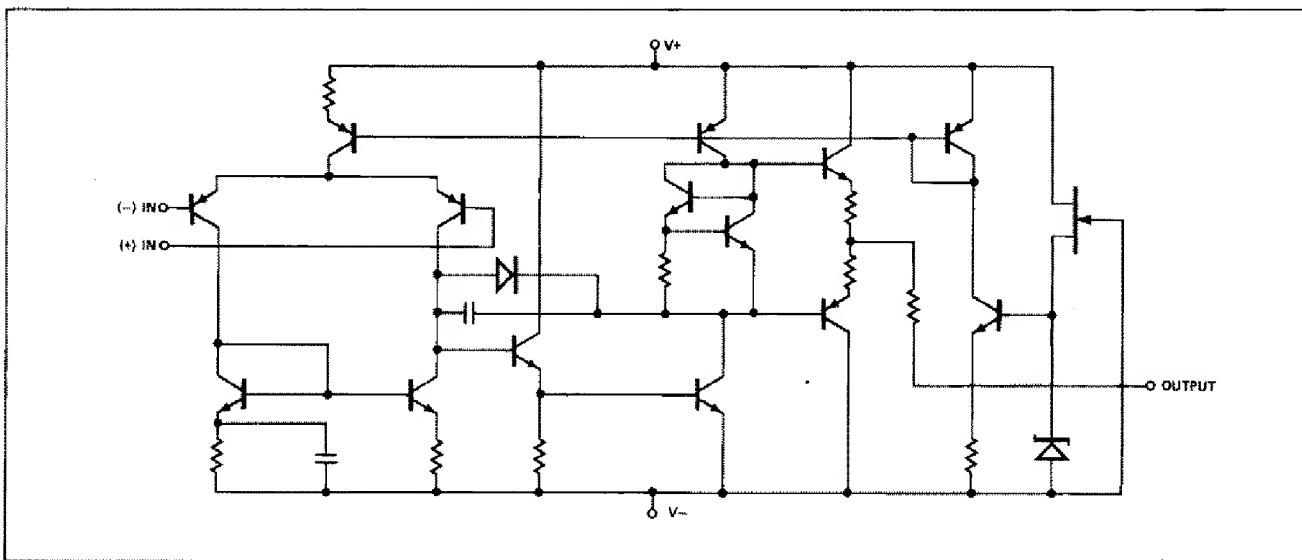
\* For devices processed in total compliance to MIL-STD-883, add /883 after part number. Consult factory for 883 data sheet.

† Burn-in is available on commercial and industrial temperature range parts in CerDIP, plastic DIP, and TO-can packages.

### PIN CONNECTIONS



### SIMPLIFIED SCHEMATIC (One of Four Amplifiers is Shown)



# OP-09/OP-11

## GENERAL DESCRIPTION

The OP-09 and OP-11 provide four matched 741-type operational amplifiers in a single 14-pin DIP package. The OP-11 is pin compatible with the LM148, LM348, RM4156, and HA4741 amplifiers. The OP-09 is pin compatible with the RM4136 and RC4136. The amplifiers are matched for common-mode rejection ratio and offset voltage which is very important in designing instrumentation amplifiers. In addition, the amplifier is designed to have equal positive-going and negative-going slew rates. This is an important consideration for good audio system performance.

Each of the four amplifiers has the proven OP-02 advantages of low noise, low drift, and excellent long-term stability. Precision Monolithics' exclusive Silicon-Nitride "Triple Passivation" process reduces "popcorn noise", provides high reliability, and assures long-term stability of parameters.

The OP-09 and OP-11 are ideal for use in designs requiring minimum space and cost while maintaining OP-02-type performance.

OP-09's and OP-11's with processing per the requirements of MIL-STD-883 are available. For dual-741-type versions, see the OP-04/14 data sheet.

## ABSOLUTE MAXIMUM RATINGS (Note 1)

|                               |       |                                    |
|-------------------------------|-------|------------------------------------|
| Supply Voltage                | ..... | $\pm 22V$                          |
| OP-09GR and OP-11GR (Only)    | ..... | $\pm 18V$                          |
| Differential Input Voltage    | ..... | $\pm 30V$                          |
| Input Voltage                 | ..... | Supply Voltage                     |
| Output Short-Circuit Duration | ..... | Continuous<br>(One Amplifier Only) |

MATCHING CHARACTERISTICS at  $V_S = \pm 15V$ ,  $T_A = +25^\circ C$ ,  $R_S \leq 100\Omega$ , unless otherwise noted.

| PARAMETER                         | SYMBOL          | CONDITIONS                               | OP-09A, OP-09E<br>OP-11A, OP-11E |     |      | OP-09B, OP-09F<br>OP-11B, OP-11F |     |     | UNITS     |
|-----------------------------------|-----------------|--|----------------------------------|-----|------|----------------------------------|-----|-----|-----------|
|                                   |                 |  | MIN                              | TYP | MAX  | MIN                              | TYP | MAX |           |
| Input Offset Voltage Match        | $\Delta V_{OS}$ |  | —                                | 0.5 | 0.75 | —                                | 0.8 | 2.0 | mV        |
| Common-Mode Rejection Ratio Match | $\Delta CMRR$   | $V_{CM} = \pm 12V$<br>$V_{CM} = \pm 12V$ | —                                | 1   | 20   | —                                | 1   | 20  | $\mu V/V$ |
|                                   |                 |  | 94                               | 120 | —    | 94                               | 120 | —   | dB        |

MATCHING CHARACTERISTICS at  $V_S = \pm 15V$ ,  $-55^\circ C \leq T_A \leq +125^\circ C$  for OP-09A, OP-09B, OP-11A, OP-11B,  $0^\circ C \leq T_A \leq +70^\circ C$  for OP-09E, OP-11E and  $-40^\circ C \leq T_A \leq +85^\circ C$  for OP-09F, OP-11F,  $R_S \leq 100\Omega$ , unless otherwise noted.

| PARAMETER                         | SYMBOL          | CONDITIONS                               | OP-09A, OP-09E<br>OP-11A, OP-11E |     |     | OP-09B, OP-09F<br>OP-11B, OP-11F |     |     | UNITS     |
|-----------------------------------|-----------------|--|----------------------------------|-----|-----|----------------------------------|-----|-----|-----------|
|                                   |                 |  | MIN                              | TYP | MAX | MIN                              | TYP | MAX |           |
| Input Offset Voltage Match        | $\Delta V_{OS}$ |  | —                                | 0.6 | 1.0 | —                                | 1.0 | 2.5 | mV        |
| Common-Mode Rejection Ratio Match | $\Delta CMRR$   | $V_{CM} = \pm 12V$<br>$V_{CM} = \pm 12V$ | —                                | 3.2 | 20  | —                                | 3.2 | 20  | $\mu V/V$ |
|                                   |                 |  | 94                               | 110 | —   | 94                               | 110 | —   | dB        |

ELECTRICAL CHARACTERISTICS (Each Amplifier) at  $V_S = \pm 15V$   $T_A = 25^\circ C$ , unless otherwise noted.

| PARAMETER                             | SYMBOL     | CONDITIONS   | OP-09A/E<br>OP-11A/E |      |     | OP-09B/F<br>OP-11B/F |      |     | OP-11C/G |      |     | UNITS             |
|---------------------------------------|------------|--|----------------------|------|-----|----------------------|------|-----|----------|------|-----|-------------------|
|                                       |            |  | MIN                  | TYP  | MAX | MIN                  | TYP  | MAX | MIN      | TYP  | MAX |                   |
| Input Offset Voltage                  | $V_{OS}$   | $R_S \leq 10k\Omega$                                 | —                    | 0.3  | 0.5 | —                    | 0.6  | 2.5 | —        | 1.2  | 5.0 | mV                |
| Input Offset Current                  | $I_{OS}$   |  | —                    | 5.5  | 20  | —                    | 25   | 50  | —        | 75   | 200 | nA                |
| Input Bias Current                    | $I_B$      |  | —                    | 180  | 300 | —                    | 300  | 500 | —        | 300  | 500 | nA                |
| Input Resistance<br>Differential Mode | $R_{IN}$   | (Note 3)   | 0.17                 | 0.29 | —   | 0.1                  | 0.17 | —   | 0.1      | 0.17 | —   | MΩ                |
| Input Voltage Range                   | IVR        |  | ±12                  | ±13  | —   | ±12                  | ±13  | —   | ±12      | ±13  | —   | V                 |
| Common-Mode<br>Rejection Ratio        | CMRR       | $V_{CM} = \pm 12V$ , $R_S \leq 10k\Omega$            | 100                  | 120  | —   | 100                  | 120  | —   | 70       | 100  | —   | dB                |
| Power Supply<br>Rejection Ratio       | PSRR       | $V_S = \pm 5$ to $\pm 15V$ ,<br>$R_S \leq 10k\Omega$ | —                    | 4    | 32  | —                    | 4    | 32  | —        | 10   | 100 | μV/V              |
| Output Voltage Swing                  | $V_O$      | $R_L \geq 2k\Omega$                                  | ±11                  | ±13  | —   | ±11                  | ±13  | —   | ±11      | ±13  | —   | V                 |
| Large-Signal Voltage<br>Gain          | $A_{VO}$   | $R_L \leq 2k\Omega$ , $V_O = \pm 10V$                | 100                  | 650  | —   | 100                  | 650  | —   | 50       | 500  | —   | V/mV              |
| Power Consumption<br>(Note 1)         | $P_d$      | $V_O = 0V$   | —                    | 105  | 180 | —                    | 123  | 180 | —        | 210  | 340 | mW                |
| Input Noise Voltage                   | $e_{np-p}$ | 0.1Hz to 10Hz  | —                    | 0.7  | —   | —                    | 0.7  | —   | —        | 0.7  | —   | μV <sub>p-p</sub> |
| Input Noise Voltage<br>Density        | $e_n$      | $f_O = 10Hz$   | —                    | 18   | —   | —                    | 18   | —   | —        | 18   | —   |                   |
|                                       |            | $f_O = 100Hz$  | —                    | 14   | —   | —                    | 14   | —   | —        | 14   | —   | nV/ $\sqrt{Hz}$   |
|                                       |            | $f_O = 1000Hz$                                       | —                    | 12   | —   | —                    | 12   | —   | —        | 12   | —   |                   |
| Input Noise Current                   | $i_{np-p}$ | 0.1Hz to 10Hz  | —                    | 17   | —   | —                    | 17   | —   | —        | 17   | —   | pA <sub>p-p</sub> |
| Input Noise Current<br>Density        | $i_n$      | $f_O = 10Hz$   | —                    | 1.8  | —   | —                    | 1.8  | —   | —        | 1.8  | —   |                   |
|                                       |            | $f_O = 100Hz$  | —                    | 1.5  | —   | —                    | 1.5  | —   | —        | 1.5  | —   | pA/ $\sqrt{Hz}$   |
|                                       |            | $f_O = 1000Hz$                                       | —                    | 1.2  | —   | —                    | 1.2  | —   | —        | 1.2  | —   |                   |
| Channel Separation                    | CS         |  | 100                  | 130  | —   | 100                  | 130  | —   | —        | 130  | —   | dB                |
| Slew Rate (Note 2)                    | SR         |  | 0.7                  | 1.0  | —   | 0.7                  | 1.0  | —   | 0.7      | 1.0  | —   | V/ $\mu$ s        |
| Large-Signal<br>Bandwidth (Note 2)    |            | $V_O = 20V_{p-p}$                                    | 11                   | 16   | —   | 11                   | 16   | —   | 11       | 16   | —   | kHz               |
| Closed-Loop<br>Bandwidth (Note 4)     | BW         | $A_{VCL} = +1.0$                                     | 2.4                  | 3.0  | —   | 2.4                  | 3.0  | —   | 2.4      | 3.0  | —   | MHz               |
| Risetime (Note 2)                     | $t_r$      | $A_V = +1$ , $V_{IN} = 50mV$                         | —                    | 110  | 145 | —                    | 110  | 145 | —        | 110  | 145 | ns                |
| Overshoot (Note 2)                    | OS         |  | —                    | 15   | 25  | —                    | 15   | 25  | —        | 15   | 25  | %                 |

## NOTES:

1. Total dissipation for all four amplifiers in package.
2. Sample tested.
3. Guaranteed by input bias current.
4. Guaranteed by risetime.

# OP-09/OP-11

ELECTRICAL CHARACTERISTICS (Each Amplifier) at  $V_S = \pm 15V$ ,  $-55^\circ C \leq T_A \leq +125^\circ C$ , unless otherwise noted.

| PARAMETER                                   | SYMBOL     | CONDITIONS  | OP-09A<br>OP-11A |          |     | OP-09B<br>OP-11B |          |     | OP-11C   |          |     | UNITS                 |
|---|------------|---|------------------|----------|-----|------------------|----------|-----|----------|----------|-----|-----------------------|
|   |            |   | MIN              | TYP      | MAX | MIN              | TYP      | MAX | MIN      | TYP      | MAX |                       |
| Input Offset Voltage                        | $V_{OS}$   | $R_S \leq 10k\Omega$                              | —                | 0.4      | 1.0 | —                | 1.0      | 3.5 | —        | 1.5      | 6.0 | mV                    |
| Average Input Offset Voltage Drift (Note 3) | $TCV_{OS}$ | $R_S \leq 10k\Omega$                              | —                | 2.0      | 10  | —                | 4.0      | 15  | —        | 4.0      | —   | $\mu V/^{\circ}C$     |
| Input Offset Current                        | $I_{OS}$   |   | —                | 20       | 40  | —                | 40       | 80  | —        | 250      | 300 | nA                    |
| Average Input Offset Current Drift (Note 3) | $TCI_{OS}$ |   | —                | 0.1      | 0.3 | —                | 0.3      | 0.6 | —        | 0.3      | 0.6 | $\text{nA}/^{\circ}C$ |
| Input Bias Current                          | $I_B$      |   | —                | 200      | 375 | —                | 400      | 650 | —        | 400      | 800 | nA                    |
| Input Voltage Range                         | IVR        |   | $\pm 12$         | $\pm 13$ | —   | $\pm 12$         | $\pm 13$ | —   | $\pm 12$ | $\pm 13$ | —   | V                     |
| Common-Mode Rejection Ratio                 | CMRR       | $V_{CM} = \pm 12V$ , $R_S \leq 10k\Omega$         | 100              | 120      | —   | 100              | 120      | —   | 70       | 100      | —   | dB                    |
| Power Supply Rejection Ratio                | PSRR       | $V_S = \pm 5$ to $\pm 15V$ , $R_S \leq 10k\Omega$ | —                | 4        | 32  | —                | 4        | 32  | —        | 10       | 100 | $\mu V/V$             |
| Large-Signal Voltage Gain                   | $A_{VO}$   | $R_L \geq 2k\Omega$ , $V_O = \pm 10V$             | 50               | 250      | —   | 50               | 250      | —   | 25       | 100      | —   | V/mV                  |
| Output Voltage Swing                        | $V_O$      | $R_L \geq 2k\Omega$                               | $\pm 11$         | $\pm 13$ | —   | $\pm 11$         | $\pm 13$ | —   | $\pm 11$ | $\pm 13$ | —   | V                     |
| Power Consumption (Note 1)                  | $P_d$      | $V_O = 0V$  | —                | 115      | 200 | —                | 115      | 200 | —        | 250      | 400 | mW                    |

ELECTRICAL CHARACTERISTICS (Each Amplifier) at  $V_S = \pm 15V$ ,  $0^\circ C \leq T_A \leq +70^\circ C$  for OP-09E, OP-11E,  $-40^\circ C \leq T_A \leq +85^\circ C$  for OP-09F, OP-11F, OP-11G, unless otherwise noted.

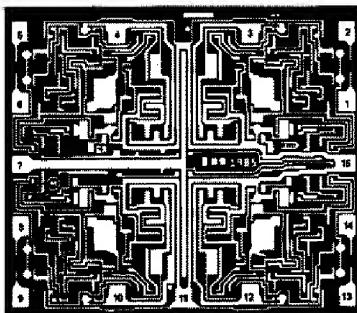
| PARAMETER                                   | SYMBOL     | CONDITIONS  | OP-09E<br>OP-11E |          |     | OP-09F<br>OP-11F |          |     | OP-11G   |          |     | UNITS                 |
|---|------------|---|------------------|----------|-----|------------------|----------|-----|----------|----------|-----|-----------------------|
|   |            |   | MIN              | TYP      | MAX | MIN              | TYP      | MAX | MIN      | TYP      | MAX |                       |
| Input Offset Voltage                        | $V_{OS}$   | $R_S \leq 10k\Omega$                              | —                | 0.4      | 0.8 | —                | 0.8      | 3.0 | —        | 1.5      | 6.0 | mV                    |
| Average Input Offset Voltage Drift          | $TCV_{OS}$ | $R_S \leq 10k\Omega$                              | —                | 2.0      | 10  | —                | 4.0      | 15  | —        | 4.0      | —   | $\mu V/^{\circ}C$     |
| Input Offset Current                        | $I_{OS}$   |   | —                | 14       | 30  | —                | 40       | 60  | —        | 250      | 300 | nA                    |
| Average Input Offset Current Drift (Note 3) | $TCI_{OS}$ |   | —                | 0.1      | 0.3 | —                | 0.3      | 0.6 | —        | 0.3      | 0.6 | $\text{nA}/^{\circ}C$ |
| Input Bias Current                          | $I_B$      |   | —                | 200      | 350 | —                | 400      | 550 | —        | 400      | 800 | nA                    |
| Input Voltage Range                         | IVR        |   | $\pm 12$         | $\pm 13$ | —   | $\pm 12$         | $\pm 13$ | —   | $\pm 12$ | $\pm 13$ | —   | V                     |
| Common-Mode Rejection Ratio                 | CMRR       | $V_{CM} = \pm 12V$ , $R_S \leq 10k\Omega$         | 100              | 120      | —   | 100              | 120      | —   | 70       | 100      | —   | dB                    |
| Power Supply Rejection Ratio                | PSRR       | $V_S = \pm 5$ to $\pm 15V$ , $R_S \leq 10k\Omega$ | —                | 4        | 32  | —                | 4        | 32  | —        | 10       | 100 | $\mu V/V$             |
| Large-Signal Voltage Gain                   | $A_{VO}$   | $R_L \geq 2k\Omega$ , $V_O = \pm 10V$             | 50               | 250      | —   | 50               | 250      | —   | 25       | 100      | —   | V/mV                  |
| Output Voltage Swing                        | $V_O$      | $R_L \geq 2k\Omega$                               | $\pm 11$         | $\pm 13$ | —   | $\pm 11$         | $\pm 13$ | —   | $\pm 11$ | $\pm 13$ | —   | V                     |
| Power Consumption (Note 1)                  | $P_d$      | $V_O = 0V$  | —                | 115      | 200 | —                | 115      | 200 | —        | 250      | 400 | mW                    |

NOTES:

1. Total dissipation for all four amplifiers in package.
2. Sample tested.
3. Guaranteed but not tested.

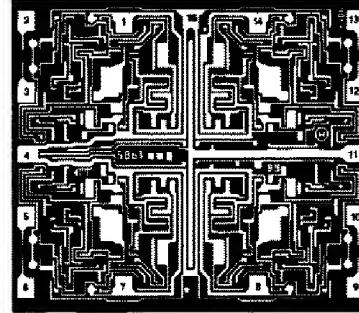
## DICE CHARACTERISTICS (125°C TESTED DICE AVAILABLE)

OP-09



DIE SIZE 0.086 × 0.072 inch, 6192 sq. mils  
(2.18 × 1.83 mm, 3.99 sq. mm)

OP-11



DIE SIZE 0.086 × 0.072 inch, 6192 sq. mils  
(2.18 × 1.83 mm, 3.99 sq. mm)

## NOTE:

Either or both V+ pads may be used without any change in performance.

**WAFER TEST LIMITS** at  $V_S = \pm 15V$ ,  $T_A = 25^\circ C$  for OP-09/11N, OP-09/11G and OP-09/11GR devices;  $T_A = 125^\circ C$  for OP-09/11NT and OP-09/11GT devices, unless otherwise noted.

| PARAMETER                           | SYMBOL   | CONDITIONS  | OP-09NT<br>OP-11NT<br>LIMIT | OP-09N<br>OP-11N<br>LIMIT | OP-09GT<br>OP-11GT<br>LIMIT | OP-11G<br>LIMIT      | OP-09GR<br>OP-11GR<br>LIMIT | UNITS         |
|-------------------------------------|----------|---|-----------------------------|---------------------------|-----------------------------|----------------------|-----------------------------|---------------|
| Input Offset Voltage                | $V_{OS}$ | $R_S \leq 10k\Omega$                                | 1.0                         | 0.5                       | 3.5                         | 2.5                  | 5.0                         | mV MAX        |
| Input Offset Current                | $I_{OS}$ |   | 20                          | 20                        | 50                          | 50                   | 200                         | nA MAX        |
| Input Bias Current                  | $I_B$    |   | 300                         | 300                       | 500                         | 500                  | 500                         | nA MAX        |
| Input Voltage Range                 | IVR      |   | $\pm 12$                    | $\pm 12$                  | $\pm 12$                    | $\pm 12$             | $\pm 12$                    | V MIN         |
| Common-Mode Rejection Ratio         | CMRR     | $V_{CM} = \pm 12V$<br>$R_S \leq 10k\Omega$          | 100                         | 100                       | 100                         | 100                  | 70                          | dB MIN        |
| Power Supply Rejection Ratio        | PSRR     | $V_S = \pm 5V$ to $\pm 15V$<br>$R_S \leq 10k\Omega$ | 32                          | 32                        | 32                          | 32                   | 100                         | $\mu V/V$ MAX |
| Output Voltage Swing                | $V_O$    | $R_L \geq 10k\Omega$<br>$R_L = 2k\Omega$            | $\pm 11$<br>$\pm 11$        | $\pm 12$<br>$\pm 11$      | $\pm 11$<br>$\pm 11$        | $\pm 12$<br>$\pm 11$ | $\pm 11$<br>$\pm 11$        | V MIN         |
| Large-Signal Voltage Gain           | $A_{VO}$ | $R_L \geq 2k\Omega$<br>$V_O = \pm 10V$              | 50                          | 100                       | 50                          | 100                  | 50                          | V/mV MIN      |
| Power Consumption (Four Amplifiers) | $P_d$    | $V_{OUT} = 0$<br>No Load                            | 200                         | 180                       | 200                         | 180                  | 340                         | mW MAX        |

## NOTES:

For 25°C characteristics of NT & GT devices, see N & G characteristics, respectively.

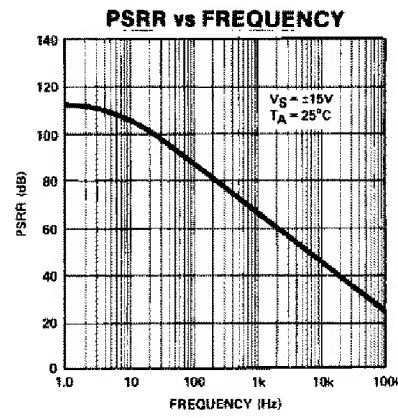
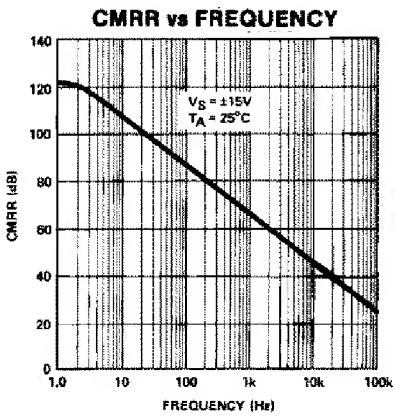
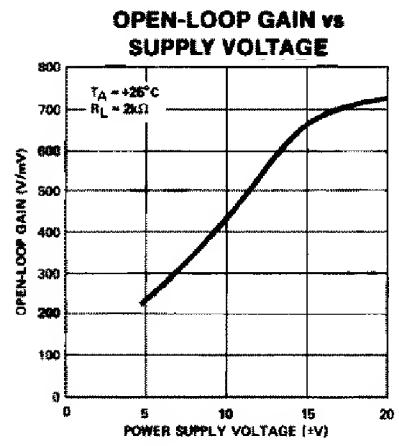
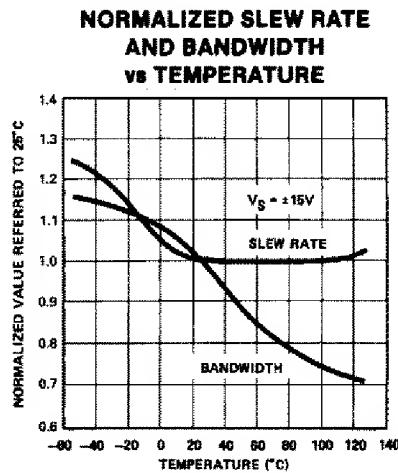
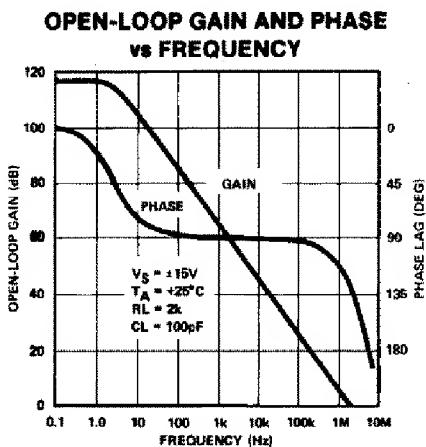
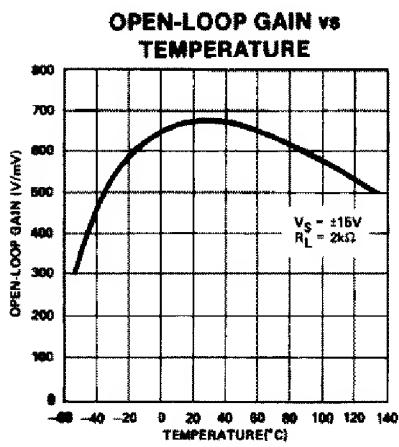
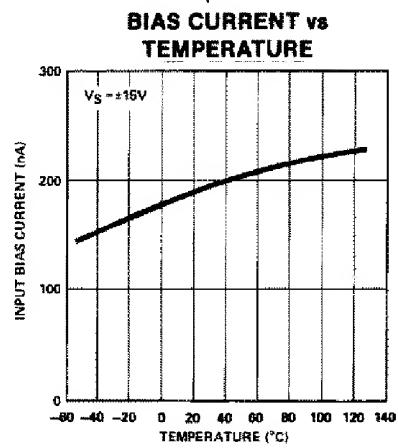
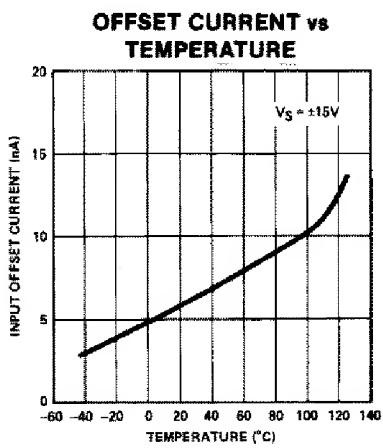
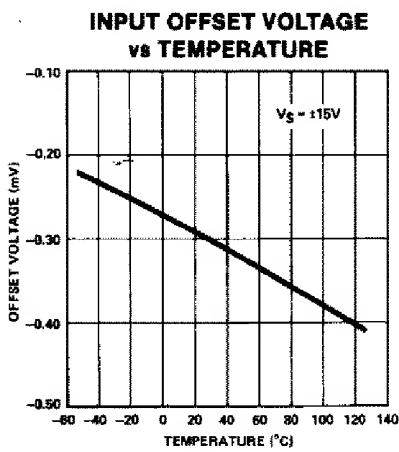
Electrical tests are performed at wafer probe to the limits shown. Due to variations in assembly methods and normal yield loss, yield after packaging is not guaranteed for standard product dice. Consult factory to negotiate specifications based on dice lot qualification through sample lot assembly and testing.

**TYPICAL ELECTRICAL CHARACTERISTICS** at  $V_S = \pm 15V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.

| PARAMETER            | SYMBOL | CONDITIONS                                     | OP-09NT<br>OP-11NT<br>TYPICAL | OP-09N<br>OP-11N<br>TYPICAL | OP-09GT<br>OP-11GT<br>TYPICAL | OP-11G<br>TYPICAL | OP-09GR<br>OP-11GR<br>TYPICAL | UNITS      |
|----------------------|--------|--|-------------------------------|-----------------------------|-------------------------------|-------------------|-------------------------------|------------|
| Slew Rate            | SR     | $A_V = 1$<br>$R_L \geq 2k\Omega$               | 1                             | 1                           | 1                             | 1                 | 1                             | V/ $\mu s$ |
| Unity Gain Bandwidth | GBW    |  | 2                             | 2                           | 2                             | 2                 | 2                             | MHz        |
| Channel Separation   | CS     | $A_V = 100$<br>$f = 10kHz$<br>$R_S = 1k\Omega$ | 130                           | 130                         | 130                           | 130               | 130                           | dB         |

# OP-09/OP-11

## TYPICAL PERFORMANCE CHARACTERISTICS



## TYPICAL PERFORMANCE CHARACTERISTICS

